

UT-2

Telluride Power Company: Nunn Hydroelectric Plant, 1897-98
SE side of Provo River, 300 ft. W. of U.S. 189, 3.5 mi. NE
of State Rt. 52, 5.3 mi. NE of Orem Bridal Veil Falls.
Utah County
Utah

HAER.
UTAH.
25-OREM.V,
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Photographs and
Written and Historical data

Historic American Engineering Record
Heritage Conservation and Recreation Service
Department of Interior
Washington, DC 20243

ADDENDUM
FOLLOWS

ADDENDUM to:

Telluride Power Company, Nunn Hydroelectric Plant
SE side of Provo River, 300 Ft. W. of U.S. Route 189
Orem vicinity
Utah County
Utah

HAER No. UT-2

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UTAH,
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WRITTEN HISTORIC AND DESCRIPTIVE DATA

Historic American Engineering Record
Rocky Mountain Regional Office
National Park Service
U.S. Department of the Interior
P.O. Box 37127
Denver, Colorado 80225

HISTORIC AMERICAN ENGINEERING RECORD

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Addendum to: Telluride Power Company, Nunn Hydroelectric Plant

HAER No. UT-2

Location: Southeast side of Provo River, 300 feet west of U.S. Route 189 and 5.3 miles northeast of Orem, Utah County, Utah

UTM: 12.448050.4465080
Quad: Bridal Veil Falls

Date of Construction: 1897-1898

Original Owner: Telluride Power Company

Present Owner: Utah Power & Light Company

Original Use: Hydroelectric generation

Present Use: Storage. With the completion of the nearby Olmsted Hydroelectric Plant (see HAER No. UT-5), the Nunn Hydroelectric Plant was taken out of service and converted into a storage facility. Today, the plant contains no historic electrical equipment, and it continues to be used for general storage.

Significance: This plant represents L. L. Nunn's first major hydroelectric generating facility outside of Colorado. At the time of completion (1898), it generated three-phase AC power at a pressure of 40,000 volts, the highest voltage of any commercial electric power system in the world.

Historian: Donald C. Jackson, 1987

The Nunn Power Plant is a 48-foot by 65-foot, single-story masonry structure with two 20-foot by 20-foot masonry wings [see plan of building in HAER Photograph No. UT-2-7]. The wings were used to house the original Leffel turbines, while the main structure contained the two 750-kilowatt, 800-volt, three-phase General Electric generators and the 40,000-volt transformers. The gable roof of the structure is a steel truss with wood planking and wood shingles. The Nunn Power Plant is now used only for storage. However, when it came "on-line" in early 1898, it represented an important advance in electric power technology. The following narrative provides a brief description of early electric power history and relates how L. L. Nunn became one of the West's most important early electric power entrepreneurs.

In the mid-19th century, electricity moved out of the scientific laboratories of the day and began to find practical commercial use. Beginning with the telegraph, electrical phenomena proved to be of economic value to corporations and society as a whole. No longer just a scientific curiosity to be used in bizarre public exhibitions, electricity began to transform a wide spectrum of human activities.

By the late 1870s, electric arc-lighting systems began to appear commercially, and they demonstrated the potential utility that electric lighting systems could offer. [1] Like many other municipalities, parts of Salt Lake City soon benefitted from an arc-lighting system manufactured by the Brush Company, based out of Cleveland. [2] Arc-lighting was a useful public improvement, but it was also a cumbersome technology that could not be readily adapted to a wide array of situations. In particular, operation of arc-lighting systems could be easily interrupted if a single light in the system malfunctioned. In well-controlled situations (such as an enclosed factor complex), such difficulties might not prove to be a major liability. But this was not the case for general public use.

In response to the limitations of arc-lighting facilities, Thomas Edison initiated work in developing a system of incandescent lighting, utilizing filament bulbs. Such a system would allow lights to be put on and off the circuit without interference to other units on the circuit. Edison's system was based upon use of direct current (DC) and also allowed for the transmission of power as well as light. In 1882, Edison's Pearly Street Station in New York City went on-line and ushered in a new era of electrical development.

Edison's direct current system proved a major financial and technological success and, within a few years, cities throughout the United States were lit and powered by franchises under license to the Edison Company. The primary limitation to these systems was that direct current could only be transmitted about seven to ten miles. Beyond this distance, "line losses" became so great that the current could not be economically transmitted. Consequently, DC systems required the use of numerous "central stations" located in the midst of the areas served. Such systems were primarily confined to densely populated regions that could provide sufficient demand to justify construction and operational costs. The limited transmission range of DC systems severely inhibited their expansion outside urban areas and beyond commercial districts.

If electric power was to find widespread use, it became apparent that practical transmission distances needed to be dramatically increased. By the late 1880s, many inventors and entrepreneurs, but not Edison, realized that systems based upon alternating current (AC) instead of direct current offered a means of obviating this problem. [3] In America, the most important early advocate of AC systems was George Westinghouse.

Allying himself with Nicola Tesla, a brilliant Yugoslavian immigrant who held several important patents in AC technology, Westinghouse set out to challenge Edison's control of the electric power industry. Edison never recognized the value of AC technology, and he doggedly fought its implementation throughout the late 1880s and early 1890s. However, Westinghouse was not dissuaded by Edison's opposition and, in the fall of 1890, his company began building the world's first commercial AC system.

The site for this pioneering effort was in the remote reaches of southwestern Colorado. Based out of Telluride, the Gold King Mining Company operated at an elevation of 12,000 feet and experienced chronic financial problems related to the cost of coal for its steam engines. [4] L. L. Nunn was a local lawyer/banker/businessman whose San Miguel Valley Bank held notes issued to the mining company. On the basis of this financial interest, Nunn gained control of the mine's management in Telluride and received approval from the firm's Eastern investors, under the leadership of James Campbell, to experiment in a new form of power production.

The company's major expenses were related to the cost of its coal-power steam engines used for hoisting and milling. Nunn sought to reduce these expenses by building a hydroelectric power system that would deliver water power generated from a nearby stream and make it available for use at the mine. The distance of the initial electrical transmission at Telluride was small (only about three miles, but it operated under a pressure of 3,000 volts, something unheard of with commercial DC systems. The high voltage allowed considerable savings in the amount of copper required for the transmission line. Extremely small, even minuscule, by modern standards, the Gold King Mine's Ames plant provided power for a 100 horsepower motor.

The Ames installation proved to be a commercial and technology success and soon spurred electric power development in the surrounding region. [5] The mining company's electrical operations were soon organized as the San Miguel Consolidated Power Company and the name was later changed to the Telluride Power Company. [6] Despite these permutations in the corporate moniker, Nunn remained in charge of all operations. In addition, he became a fervent advocate of AC electric power systems and soon sought ways to expand his involvement in the field into other Western mining districts. Within a few years, this would lead him to developing hydroelectric power projects along the Provo River in Utah. But before this occurred, a critical refinement in AC technology needed to take place.

When Westinghouse installed its first AC system at Telluride, it only involved the use of a single line of AC current. Known as a single-phase system, the Telluride facility was perfectly capable of transmitting electricity for lighting purposes. It was also capable of power transmission, but the operation of single-phase AC motors was much more problematical and not as reliable as Westinghouse and the mining company would have liked. This was especially true when more than two motors were connected to the transmission line.

As L. L. Nunn's brother and business partner, P. N. Nunn, later put it, "[after two motors were in operation] each [additional] motor added to the system brought increased demand for care and skill." For a mining operation that operated only a few motors and controlled all aspects of the power generation and transmission system within a relatively small geographical area, a single-phase AC system represented a viable proposition. But for more widespread utilization, single-phase AC systems were not practical for power transmission purposes. [7]

Single-phase AC systems were superior to DC systems in their ability to use high voltages and their ability to transmit current long distances. This was demonstrated in Westinghouse's 1892 installation at Pomona, California, that operated under a pressure of 10,000 volts and transmitted current 28 miles for lighting purposes. [8] But DC was still better than single-phase AC for power transmission. The solution to this problem did not lie in abandonment of AC technology for a new type of DC technology. Instead, it lay in developing a new form of AC transmission.

In their early work on AC technology, Tesla and other researchers recognized that alternating currents could transmit power through the creation of "rotating magnetic fields." However, this was only possible if more

than one line of AC current was being transmitted. In polyphase systems, more than one line of AC current is produced by the generator. If these currents are generated out of phase with one another and, if connected with polyphase motors that are compatible with the generators, they can produce a "rotating magnetic field" capable of inducing large amounts of power.

It is beyond the scope of this report to discuss the theoretical basis of polyphase technology, the economic advantages of three-phase vs. two-phase systems, or how polyphase systems became the standard throughout the United States and most of the world by the early 20th century. But, during the early 1890s, polyphase AC technology was established as a viable commercial proposition in both America and Europe. [9] The first polyphase system in the United States went on-line in the fall of 1893 in Redlands, California. Designed by Almerian Decker, in concert with the engineering staff of General Electric Company (a firm created after Edison left the field of electric power that included the former Edison General Electric Co. and the Thomson-Houston Electrical Manufacturing Company), the Redlands plant established California as the center of long distance polyphase transmission developments.

In California, most of the high voltage, long distance transmission systems were for general municipal use and provided power for lighting, irrigation pumping, streetcar operations and a variety of industrial functions. In contrast, Nunn's Telluride Power Company was oriented almost exclusively towards powering mining operations. These were much more controlled in terms of power demand and operation, and Nunn kept his single-phase system in Telluride operation until 1896. Only at that time did he switch to a polyphase system that would allow for more reliable and varied, use of motors in the numerous mines served by the company. [10]

Nunn Power Plant

During the mid-1890s, L. L. Nunn and his brother, P. N. Nunn, chose to expand their involvement in electric power development beyond the gold mining district of southwestern Colorado. In particular, they were attracted to the Utah Lake region in central Utah and the large-scale mining operations that were underway in the Mercur and Eureka districts west and south of Provo. Drawing upon the experience accrued at Telluride, L. L. Nunn wished to construct electric power systems that would dramatically reduce mining expenses at these locations. In turn, this would provide him and his company with a very profitable investment.

The Provo River offered a large water supply and comprised the site of Nunn's first foray into power projects outside of Colorado. [11] In 1895, Nunn announced his plans to build a dam and polyphase hydroelectric power plant in the Provo Canyon between Heber City and Provo. Nunn initially intended to construct a large storage dam to serve this plant, but he soon encountered opposition from water users in the Utah Lake Valley and from the Denver and Rio Grande Railroad who were planning to build a line up the canyon. As a result, Nunn was forced to abandon his plans for an 80-foot-high dam and settle for a small diversion structure only 15 feet high. This alteration meant that the railroad right-of-way would not be inundated and that the power plant would not disturb the availability of water along the lower reaches of the river.

In fact, Nunn was fortunate that the narrow confines of the Provo Canyon prevented any substantial agriculture development from occurring in the immediate area. Otherwise, this could have precluded any water diversion for water production from taking place. As it was, the Nunn Plant (as it came to be known) diverted water from the Provo River, used in power generation, and returned it to the streambed without interfering with any irrigation systems. [12]

The Nunn Plant came on-line in early 1898 and provided power to Mercur (a mining community west of Uthal Lake) over a 32-mile-long transmission line. The equipment in the plant consisted of two 750 kilowatt, three-phase generators that were driven by turbines operating under a head of 120 feet. A bank of transformers raised the voltage from 800 volts to 40,000 volts, in order to facilitate the long distance transmission of power. The water was carried in an 8,000-foot-long wooden flume before reaching the penstocks that descended down to the powerhouse.

In terms of its hydraulic technology, there was nothing particularly remarkable about the Nunn plant. But the 40,000 volt transmission line to Mercur constituted the highest voltage line in the world used for commercial (rather than experimental) purposes. [13] Nunn's original installation at Telluride had pioneered in the use of high voltage, single-phase current. After expanding into Utah, he continued in this tradition by helping to develop high voltage, polyphase systems. At Provo, he worked with General Electric engineers in designing and constructing the transmission line and benefited from the electrical manufacturing company's recent work in California. [14] But the vision behind the Provo-Mercur transmission line largely came from Nunn and it was through his persistent efforts that it became operational.

The Nunn plant proved to be a valuable source of power for mining companies in Mercur and, within a few years, a second transmission line was built from the facility. Operating under a similar voltage, the new line extended 42 miles to the mining operations at Eureka, a community about 28 miles south of Mercur on the southwestern shore of Utah Lake. With this development, the Nunn plant reached the limit of its power production. Although a regional market for the Telluride Power Company's was clearly available, the firm's original plant on the Provo River could not produce any additional power because of hydraulic, not electrical, limitations. [15] If the company was to increase power production, it needed to completely replace the Nunn plant.

In 1903, the company began work on a new power plant downstream from the Nunn Power Plant that would operate under a much higher "head" than the original facility. Known as the Olmsted Plant, this installation came "on-line" in 1904 (see HAER No. UT-5). For a few years, the company kept the Nunn Power Plant on "stand-by" in case it was needed during an emergency. However, in the 1920s all electrical equipment was removed from the plant and since that time it has only been used for general storage.

- [1] See Thomas P. Hughes, Networks of Power: Electrification in Western Society, 1880-1930, (Baltimore, MD: The Johns Hopkins University Press, 1984), for basic information on the history of electric power development in the United States and Europe. Arc-lighting technology is described on pp. 87-88.
- [2] Salt Lake City's early Brush lighting system is briefly described in "Utah Power & Light Company," Electrical West 129, August 1962, pp. 294-307. Early lighting systems in Utah are also described in Kate B. Carter, compiler, "Development of Lighting Systems in Utah," January 1944, pamphlet on file at the Utah State Historical Society Library.
- [3] For a detailed discussion of the "battle of the systems," see Hughes, Networks of Power, pp. 106-139.
- [4] Early electric power developments at Telluride are described in P. N. Nunn, "Pioneer Work in High Tension Electric Power Transmission: The Operation of the Telluride Power Company," Cassier's Magazine 27 (January 1905): 171-200; and Charles C. Britton, "An Early Electric Power Facility in Colorado," Colorado Magazine 49 (1972): 186-195.
- [5] For discussion of the numerous mines that eventually received power from the Telluride Power Company, see Nunn, "Pioneer Work in High Tension Electric Power Transmission." This article includes a map (p. 182) of the territory served by the company. The Westinghouse Company's involvement in experimental work at Telluride in the early 1890s is noted in Hughes, Networks of Power, pp. 162-163.
- [6] The name changes and corporate history of Nunn's hydroelectric power empire are given in "Utah Power & Light Company: History of Origin And Development, (Prepared in Connection with Federal Power Request Order Dated May 11, 1937," pp. 8-14. This typewritten manuscript is dated January 28, 1941, and is located in the historical files of the Utah Power & Light Company, Salt Lake City. The author thanks Dr. John McCormick of the Utah State Historical Society for making this document available.
- [7] The quotation is taken from Nunn, "Pioneer Work in High Tension Electric Power Transmission," p. 183. Other single-phase systems (such as a municipal facility at Portland, Oregon) were built by Westinghouse with hopes that they could be utilized for power as well as lighting. However, this soon proved to be an unrealistic expectation.
- [8] The 1892 Pomona system is described in George Low, "10,000 Volt Alternating Current Long Distance Transmission at Pomona, California," Electrical Engineer 16 (August 2, 1893): 97-99.
- [9] See Chapter Four in Donald C. Jackson, "A History of Water in the American West: John S. Eastwood and 'The Ultimate Dams' (1908-1924)," unpublished Ph.D. dissertation, University of Pennsylvania, 1986, for a detailed discussion of the early development of polyphase transmission systems.
- [10] The switch from single-phase to polyphase technology at the Ames Plant in 1896 is discussed in Nunn, "Pioneer Work in High Tension Electric Power Transmission," p. 183.

- [11] Nunn's entry into Utah is described in "Utah Power & Light Company, History of Origin and Development," pp. 123-129.
- [12] The placement of the 1897 Nunn plant within the center of irrigation development on the Provo River is noted in Mead, Report on Irrigation Investigation in Utah, p. 108.
- [13] This is described in Leon W. Bly, "The Provo-Mercur 40,000-Volt Transmission," Journal of Electricity 5 (June 1898): 169-173.
- [14] General Electric had proven the reliability of long distance three-phase transmission systems with their pioneering work in California. The critical early commercial uses of this technology had been at Redlands (on-line in September 1893), Sacramento (on-line in September 1895), and Fresno (on-line in April 1896). The latter two systems (both 11,000 volts) were 22 miles long and 35 miles long respectively.
- [15] The Nunn plant on the Provo River was originally built and operated by a corporate entity known as L. L. Nunn, Trustee. In 1900, the Telluride Power Company formally took control of all assets previously held by L. L. Nunn, Trustee. See "Utah Power & Light Company: History of Origin and Development," p. 131.